

**Figure 8-13.—Batch asphalt plant hatching unit aggregate weigh-hopper.**

Bulk or bag filler systems are equally adaptable for continuous-flow asphalt plants. Final metering of the filler to the mix is accomplished through a variable speed vane, a screw feeder, or a belt feeder, depending on the material to be handled and the capacity required. In each case, the mineral filler feed is interlocked with the aggregate and asphalt feed to ensure constant accuracy.

When an excess of filler is encountered in the raw aggregate feed, a bypass system can be used to receive the fines collected by the dust collector. The

required amount of fines is then fed back to the mix, and any surplus amounts are diverted to a storage bin for disposal or other use.

### BATCH ASPHALT PLANT

The batch asphalt plant is shown in figure 8-1. The cold aggregate storage and feed system, dryer, and dust collector are both similar in operations for both the batch and continuous-flow type of asphalt plant. A distinguishing feature of the batch plant is the batching unit shown in figure 8-13. Here the dried hot aggregate

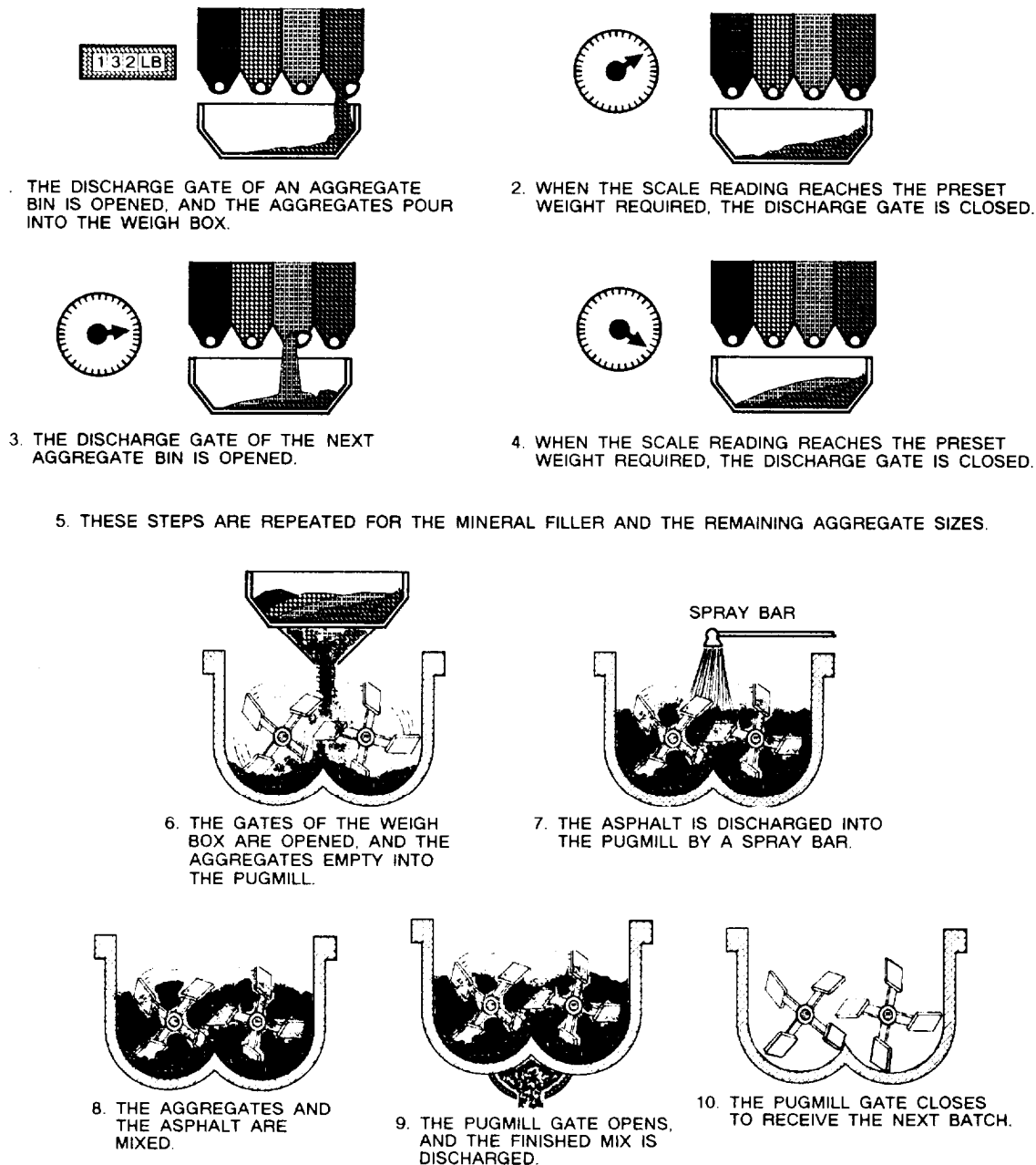


Figure 8-14. Typical batch plant cumulative scale settings and cycle.

is screened into different sizes and stored by size in separate bins.

From the hot bins the aggregates are deposited into a weigh-hopper. Coarse aggregates are usually the first to be deposited into the weigh-hopper, the intermediate-size aggregates next, and the fine aggregates last. This sequence is designed to place the fines of the aggregates at the top of the aggregates deposited in the weigh-hopper where they cannot leak out through the gate at the bottom of the weigh-hopper. This system also allows the most efficient utilization of

the available volume in the weigh-hopper. The weigh-hopper is suspended from scale beams and the scales indicate the weight of the full amount of aggregate entering the hopper.

When each size of aggregate is deposited into the weigh-hopper, the weights to be drawn from the hot bins are marked on the scale dial. Because the scales indicate the weights cumulatively, the dial must be marked accordingly. Figure 8-14 shows how the cumulative scale settings are used to control the proportion of aggregates drawn from each bin.

## Asphalt Introduction

From the weigh-hopper, the aggregates are deposited into the plant pugmill (mixing chamber) and are blended with the proper proportion of asphalt. In a typical plant system, asphalt is weighed separately in a weigh bucket before being introduced into the pugmill. When the asphalt reaches a predetermined level in the weigh bucket, a valve in the delivery line closes to prevent excess asphalt from being discharged into the bucket. The asphalt is then pumped through spray bars into the pugmill. Asphalt buckets should be checked for accuracy in the mornings. New asphalt loosens some of the old asphalt that accumulated the previous day on the sides and bottom of the bucket. Loss of this accumulated asphalt changes the tare weight of the bucket.

### Pugmill Mixing

Asphalt and aggregates are blended in a chamber called the pugmill. The pugmill consists of a lined mixing chamber with two horizontal shafts on which several paddle shanks, each with two paddle tips, are mounted. The paddle tips are adjustable and fairly easily replaced.

The paddle areas are adjusted to ensure there are no "dead areas" in the pugmill. A "dead area" is a location where aggregates can accumulate out of reach of the paddles and not be thoroughly mixed. Dead areas can be avoided by making sure the clearance between the paddle tips and the liner is less than one half of the maximum aggregate size.

Nonuniform mixing can occur if the pugmill is overfilled (fig. 8-15). When the plant is operating at full production, the paddle tips should be barely visible at the surface of the material during mixing. If the material is too high, the surface aggregates will tend to "float" above the paddles and will not thoroughly mix. Conversely, in a pugmill containing too little aggregate (fig. 8-15), the tips of the paddles rake through the material without mixing it. These problems can be avoided by following the manufacturer's pugmill batch rating recommendation. Normally, the rating is based on a percentage of the capacity of the pugmills "live zone." This live zone (fig. 8-15) is the net volume in cubic feet below a line extending across the top are of the inside body shell radius with shafts, liners, paddles, and tips deducted.

Figure 8-14 presents the mixing cycle during which the aggregates, mineral filler, and asphalt are blended in asphalt hot mix in the pugmill. The length of time

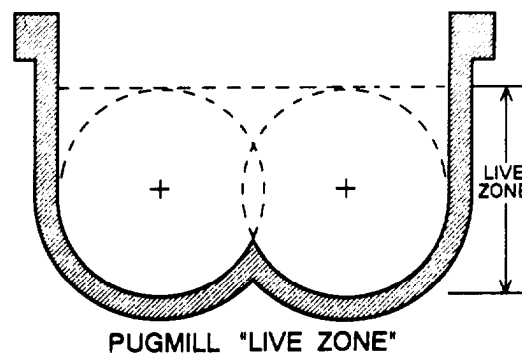
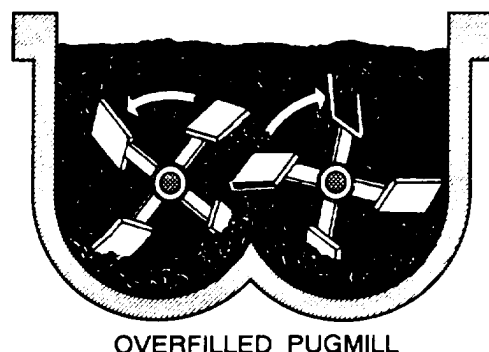
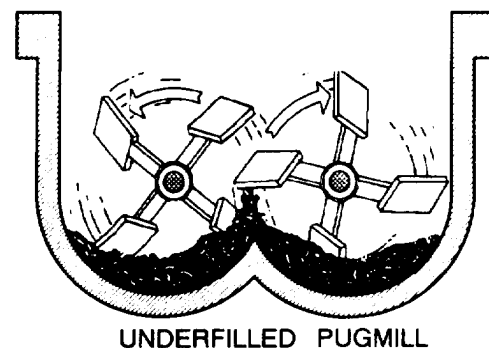


Figure 8-15.-Typical pugmill.

between the opening of the weigh box gate (Step 6 in the figure) and the opening of the pugmill discharge gate (Step 9) is referred to as the batch mixing time. The batch mixing time must be long enough to produce an homogeneous mixture of evenly distributed and uniformly coated aggregate particles. If the mixing time is too long, the lengthy exposure of the thin asphalt film to the high-aggregate temperature in the presence of air can affect the asphalt and reduce the durability of the mix. The speed of the mixer shafts and the arrangement and pitch of the paddles are factors governing the efficiency of the mixing. Most job specifications require the use of a timing device to monitor batch mixing time.

## Discharge Gate

Little time is lost in discharging a completed batch through the hydraulically actuated discharge gate because there is no segregation of materials. The gate opens across the entire length of the paddle shafts and across the width (distance between the paddle shaft centers) of the pugmill. Being relatively large, the gate opening permits access from the bottom for maintenance and replacement of parts.

## Plant Automation

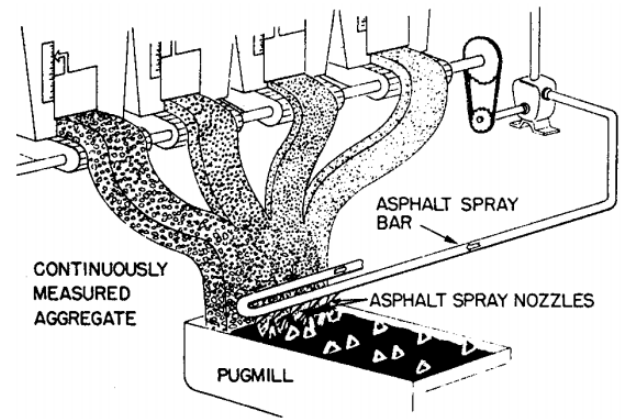
The batch asphalt plant is almost completely automated. After mix proportions and timers are set and the plant is started, the plant repeats the weighing and mixing cycles until stopped by the operator or until a shortage of material or some unexpected malfunction causes the plant to shut down itself.

The plant operator's manual provided by the manufacturer, provides details on the setup and adjustment of the automatic equipment. You must check the accuracy and adjustment of this equipment, particularly the aggregate scales, asphalt scales or meters, batching controls, and recording equipment (if used). This should result in trouble-free production; moreover, the entire plant should be checked periodically to ensure the finished product meets specifications.

## CONTINUOUS-FLOW ASPHALT PLANT

The continuous-flow asphalt plant is shown in figure 8-2. Continuous-flow asphalt plants are equipped with positive displacement asphalt pumps. One type is regulated by changing the drive sprockets or gears that are mechanically interlocked with the aggregate feeders (fig. 8-16). The other is controlled by a calibrated remote control handwheel on the mixer operator platform. When using the former type, you must use the manufacturer's tables as a basis for determining the proper pump and sprocket combinations to fix the amount of asphalt discharge. By doing so, you can control the feeder gates and asphalt pump while ensuring no change in setting can be made without the knowledge of the asphalt plant supervisor.

The temperature of the asphalt going through the positive displacement asphalt pump must be known at all times to maintain constant asphalt proportioning. You should take frequent readings of the thermometer installed in the circulating line just ahead of the pump. This allows you to make any necessary adjustments to



**Figure 8-16.-Spray-bar operation with asphalt distribution mechanically interlock with aggregate feeders.**

compensate for volume changes in the asphalt when substantial temperature changes occur.

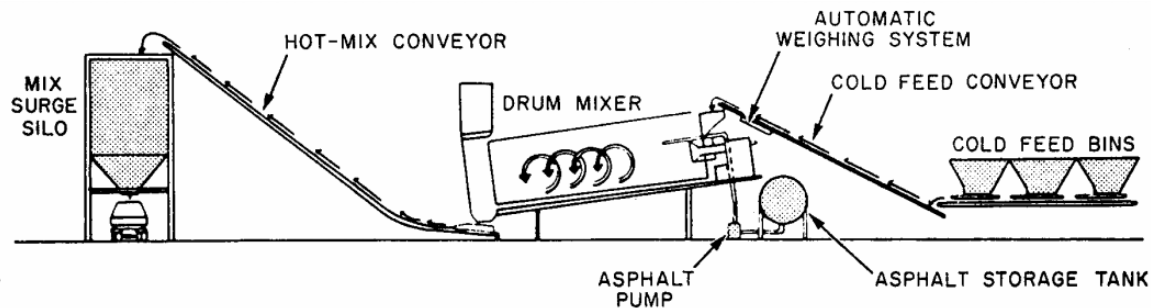
## Pugmill Mixer

The function of a continuous-flow plant pugmill is almost identical to the pugmill in the batch mix plant. The primary difference is that the mixing principle is different. In a batch mixer, the materials are confined in the mixing chamber. In a continuous-flow plant pugmill mixer, the materials are propelled toward the discharge. The mixing pressure varies with the height or weight of material in the pugmill that can be controlled by adjusting the dam gate at the discharge. The height of material in the pugmill mixer should not be allowed to rise above the paddle tips, with the exception of the last set of paddles.

To improve the mixing efficiency of the pugmill, you should make the following adjustments:

1. Raise the dam on the discharge end of the mixer to hold the material in the mixing unit for a longer period of time at a depth that will further intensify the mixing action.
2. Adjust or reverse the pitch of the paddles to retard movement of the material through the pugmill and increase the degree of mixing action within the unit.

Nonuniform mixing can occur if the mixer is overfilled. At maximum operating efficiency, the paddle tips should be barely visible in the material at the top of the arc during mixing. The batch rating of the pugmill for the continuous-flow plant is the same as for the batch plant.



**Figure 8-17.-Basic drum-mix asphalt plant**

## Mixing Time

Total mixing time begins when all the combined mineral aggregates are in the mixer and ends when the mixer discharge gate is opened. Dry mixing time, when specified, begins when all the combined mineral aggregates are in the mixer and ends with the introduction of the asphalt. Wet mixing time begins with the start of the asphalt application and ends with the opening of the mixer discharge gate.

The asphalt film on aggregate is hardened by exposure to air and heat; therefore, mixing time should be the shortest time required to obtain a uniform distribution of aggregate sizes and a uniform coating of asphalt on all aggregate particles. The speed of the mixer shafts and the arrangement and pitch of the paddles are factors governing the efficiency of the mixing.

To aid further the operation of a continuous mix plant, you can add or extend several automatic controls. These include the following:

1. Automatic burner controls
2. Automatic mix discharge
3. Automatic mixer and gradation cutoffs in case of hot-bin shortage or improper feed
4. Electric interlocks that shut down the complete plant in case of a failure anywhere in the electric system

The operator's manual for the particular plant being used gives details on the setup and adjustments of the automatic equipment included with the plant.

**NOTE:** Normally all automatic systems have manual override. You should know where it is located and how to use it. See the manufacturer's manual for specific details.

## DRUM-MIX ASPHALT PLANT

The drum-mix plant is shown in figure 8-3. The mixing drum for which the plant is named is very similar in appearance to the batch plant dryer drum. The difference between the two is that in a drum-mix plant the aggregate is not only dried and heated within the drum, but it is also mixed with the asphalt cement. In a drum-mix plant, there are no gradation screens, hot bins, weigh-hoppers or pugmills. Aggregate gradation is controlled at the cold feed.

The basic plant consists of a cold-feed system, a rotating drum dryer, an asphalt proportioning and dispensing system, and a surge silo (fig. 8-17). The ease of setup and operation of the drum-mix plant makes it the ideal machine for operations.

## Aggregate Storage and Feed

Aggregate gradation and uniformity are entirely dependent on the cold-feed system. Proper care must be exercised not only in producing the aggregate but also in storage. Aggregates used for drum-mix plants must be received, handled, and stored to ensure there is no danger of contamination or intermingling.

Stockpiles must be properly graded and split into different sized fractions to control the gradation of the mix properly. Uncorrected segregated stockpiles will result in mix gradation difficulties. The plant supervisor should establish and maintain stockpiles in the most economical manner and correct any deficiencies in uniformity before the aggregate is fed into the mixing plant.

Since the typical drum-mix plant does not have a gradation unit, the aggregate must be proportioned before entering the mixing drum. This is accomplished with a multiple-bin cold-feed system equipped with precision belt feeders for control of each aggregate.

Under each bin is a belt feeder upon which the aggregate is proportioned.

The plant should be equipped with a means to obtain samples of the full flow of aggregates from each cold feed and the total cold feed. These samples are required to perform a sieve analysis of the dried aggregate.

Cold feed controls consist of the following:

1. Sieve analysis of aggregate in each bin.
2. Calibrate feeders—both belt speed and gate opening.
3. Established bin proportions.
4. Set belt drive speeds and gate openings.

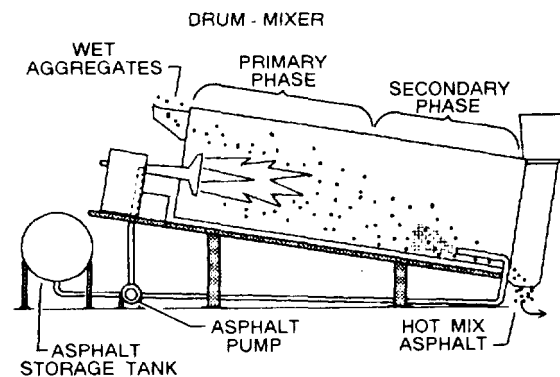
Once the gates are calibrated, they should be checked regularly to ensure they remain properly set. All settings should be considered tentative because the cold aggregate used in the mix normally varies in grading and moisture content; therefore, adjustment of the gates is required to maintain a uniform flow.

Drum-mix plants require the use of a continuous weighing system on the cold-feed conveyer belts. In-line belt weighers, known as weigh bridges, are belt-weighing devices used to weigh the combined aggregate passing over the conveyer belt. A readout indicates the weight of the flow over the scales at any given instant. No material should ever be diverted from the conveyer belt after it passes the belt weigher.

The in-line belt weigher is usually located between the head and tail pulley of the cold-feed belt conveyer. This location tends to lessen variations in readings caused by impact loading, rollback of aggregate, or changes in belt tension.

In drum-mix plants the aggregate is weighed before drying. Undried aggregates may contain an appreciable amount of moisture that can influence the weight; therefore, an accurate measurement of the moisture content is important. From the weight measurement, adjustments can be made to the automatic asphalt metering system to ensure that the amount of asphalt delivered to the drum is correct for the amount of aggregate minus its moisture content.

The moisture content of the cold-feed aggregates should be monitored at the beginning of each day and about the middle of the day. When conditions make the moisture content vary, it should be checked more frequently.



**Figure 8-18.-Drum mixer zones**

### Asphalt Metering

The drum-mixer is normally equipped with a system to add asphalt to the aggregate inside the drum mixer. Called the asphalt metering and delivery system, it is a continuous mechanical proportioning system interlocking with the aggregate weigh system to ensure the exact asphalt content of the mix. The weight of the aggregate delivered into the mixer, as measured by the weigh belt, is the basis for determining the quantity of asphalt delivered into the drum.

Asphalt proportioning is accomplished by establishing the necessary rate of asphalt delivery in gallons per minute to match the aggregate delivery in tons of dry aggregate per hour. The asphalt delivery rate is adjusted to correspond to the weight measurement of the aggregate passing over the belt scale.

### Drum-Mix Operation

The mixer is the heart of a drum-mix plant. Compared to a conventional batch plant rotary dryer, the mixer is similar in design and construction except that the drum-mixer can be divided into two sections: (1) a primary or radiation zone and (2) a secondary or convention/coating zone (fig. 8-18).

Aggregates enter the primary zone where heat from the burner dries and heats it. Then the aggregate moves to the secondary zone where asphalt is added, and aggregates and asphalt are thoroughly blended. Continued drying also occurs in the secondary zone. The mixture of hot asphalt and moisture released from the aggregate produces a foaming mass that traps the fine material (dust) and aids in the coating of the larger particles.

Drum-mixers are equipped with flights to direct the aggregate flow and spread the aggregates into a veil

across the cross section of the drum. The aggregates must not only rotate with the revolving motion of the drum but must also spread out sufficiently to make heating and drying of all particles quick and efficient.

The spiral flights are located at the charging (burner) end of the drum-mixer and direct wet aggregates into the drum in such a manner as to attain uniform drum loading. Tapered lifting flights pick up the aggregates and drop them in an even veil through the burner flame.

### **Burner Operation**

The burner inside the drum-mixer provides the heat necessary to heat and dry the aggregates used in the final mixture. The burner provides this heat by burning fuel oil, gas, or both.

When oil is burned, a low-pressure air draft is used to atomize the fuel oil for burning. Depending on the type of fuel used for the burners, the fuel feed and air blower must be balanced to ensure that the proper proportions of fuel and air are being introduced into the burner to ensure efficient combustion. Lack of balance can lead to incomplete burning of the fuel. Especially, when fuel oil or diesel fuel is used, this can leave an oily coating on the aggregate particles. An imbalance between the fuel feed and air flow can be adjusted by either decreasing the fuel rate or increasing the blower or draft air.

### **Surge Silo**

The drum-mix plant produces a continuous flow of fresh asphalt hot mix and has a surge silo for temporary storage of the hot-mix material. The surge silo is also used for controlled loading of trucks. A weight system is normally connected to the holding bin of the silo to monitor the amount of hot mix loaded into each truck. Weight measurements are normally recorded by the weight system control panel.

## **BITUMINOUS SURFACING MATERIALS**

Bituminous materials are tremendously important in the construction of roads and airfields for both military and civilian use. A basic knowledge of these bituminous materials, their origin, composition, types, and grades are essential for an understanding of their use in construction.

Bituminous surfaces are composed of compacted aggregate and bitumen (binder). The aggregate

transmits the load from the surface to the subgrade, takes the abrasive wear of the traffic, and provides a nonskid surface. The binder binds the aggregate together, thus preventing the displacement and loss of the aggregate. The binder also provides a waterproof cover for the base that keeps surface water from seeping into and weakening the material.

Bituminous surfaces are particularly adaptable to stage construction. Additional courses can be added to existing pavements to provide further reinforcement when loads or traffic density increases. The flexibility of bituminous surfaces permits slight adjustment caused by settlement of the subgrade without detrimental effect. Properly designed bituminous wearing surfaces, when compared with concrete, are less affected by temperature strains. The surfaces resist wear, weathering, and deterioration from aging with only minimal maintenance.

Bituminous materials are highly versatile and serve admirably in temporary, expedient, and light traffic situations where concrete is not justifiable. It is equally true that thicker bituminous pavement designed for heavy and continuing duty is fully comparable to concrete designed for heavy volumes of traffic or heavy wheel loads; however, bituminous wearing surfaces lack appreciable bearing action to carry wheel loads over weak spots in the subbase. For this reason, the subgrade must have an adequate, uniform bearing strength and the base course must have adequate thickness, bearing capacity, and cohesion.

## **TYPES AND GRADES OF ASPHALT**

Asphalt is a natural or man-made by-product of petroleum distillation. Natural asphalt is found in nature as either lake (or pit) asphalt or rock asphalt. The common bituminous surfacing materials are asphalt cements, asphalt cutbacks, asphalt emulsions, road tars, and road tar cutbacks. For identification purposes, these materials are divided into three classes: asphalt bitumens, emulsions, and tars. The classification of these materials is based on the extent to which they dissolve in a distillate of petroleum or coal. Asphalt cements and asphalt cutbacks are asphalt bitumens (or asphalts). Road tars and road tar cutbacks are tars.

### **Asphalt Cements**

Asphalt cements are solid products of petroleum refining (fig. 8-19). An asphalt cement is designated by the letter symbol AC, followed by the penetration grade that represents its relative hardness. The numbers range

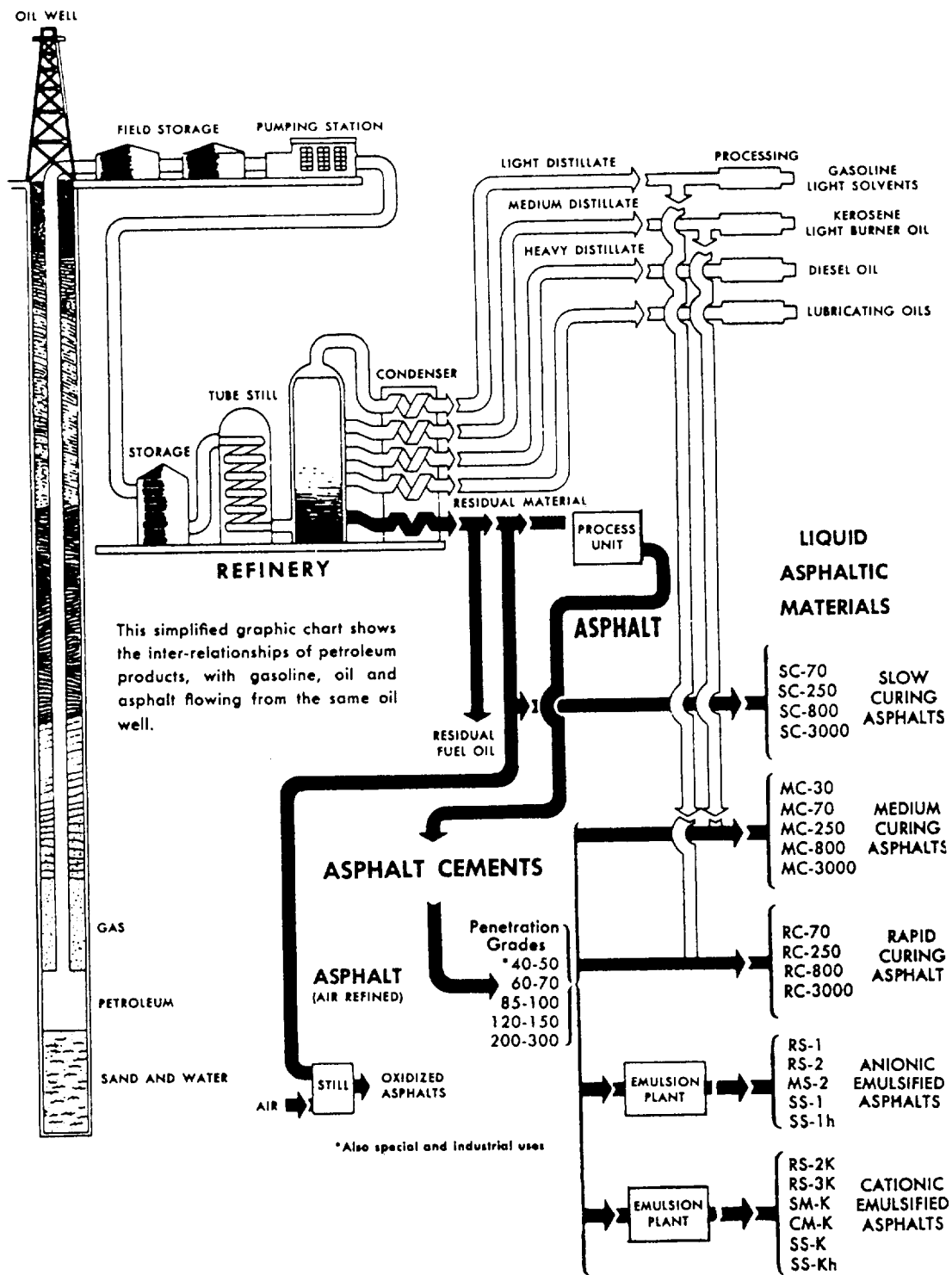


Figure 8-19.-Petroleum asphalt flow chart.

Table 8-2.-Penetration Grade and AP Number of Asphalt Cement

Penetration grade	AP No.	Relative consistency
40-50	7	Hard
60-70	5	
85-100	3	Medium
120-150	1	
200-300	00	Soft

Table 8-3.-Asphalt Cutback Composition (Expressed in Percent of Total Volume)

Type	Components		Grades				
		Solvent	30	70	250	800	3,000
Rapid curing RC	Asphalt cement	-----	---	65	75	83	87
		Gasoline or naphtha -----	---	35	25	17	13
Medium curing MC	Asphalt cement	-----	54	64	74	82	86
		Kerosene -----	46	36	26	18	14
Slow curing SC	Asphalt cement	-----	---	50	60	70	80
		Fuel Oil -----	---	50	40	30	20

from 40 (hard) to 300 (soft) (table 8-2). The number is derived from a penetration test that is the distance that a standard needle penetrates the asphalt cement under a standard loading weight, in a given time, under known temperature conditions.

All asphalt cements are solid or semisolid at room temperature (77°F) and must be converted to a fluid for mixing with aggregate or for spraying. Asphalt cement must be heated to a temperature ranging from 250°F to 350°F, depending upon the grade of the asphalt cement.

The various penetration grades of asphalt cement are suitable for different uses, such as plant mixes, penetration macadam, and surface treatment. Soft penetration grades of asphalt cement are preferred for use in cold climates, medium grades in moderate climates, and hard grades in warm climates.

### Asphalt Cutbacks

The special equipment needed to heat asphalt cements is not always available. Since asphalt must be

in a fluid condition to spray or to mix with an aggregate, the solid asphalt cement would not be suitable. Asphalt cement (AC) can be made fluid by adding solvents called *Cutterstock* or *Flux Oil*. Cutterstock may be any one of the more volatile petroleum distillate products. The resulting combination is called *Asphalt Cutback*. Exposure to air causes the petroleum distillate to evaporate and leave the asphalt cement to perform its function.

The rate of evaporation determines the type of asphalt cutback that is in the mixture. Gasoline or naphtha (highly volatile) will produce a rapid-cure cutback (RC) with a curing time of 4 to 8 hours; kerosene (medium volatility) will produce a medium-curing cutback (MC) with a curing time of 12 to 24 hours; and a fuel oil (low volatility) will produce a slow-curing cutback (SC) with a curing time of 48 to 60 hours. Table 8-3 shows the percentage of components by grade for the three types of asphalt cutbacks.

**Table 8-4.-Asphalt Emulsions According to Their Electric Charge**

Kind	Type	Viscosity Grade	Mixing Ability
Anionic	RS	RS-1, RS-2	Spraying
	MS	MS-2	Mixing and spraying
	SS	SS-1, SS-1h	Mixing and spraying
Cationic	RS-C	RS-2C, RS-3C	Spraying
	MS-C	SM-C	Mixing (sand) and spraying
	MS-C	CM-C	Mixing (coarse aggregate) and spraying
	SS-C	SS-C, SS-Ch	Mixing and spraying
Note: C – denotes cationic emulsion. h – denotes a lower penetration grade of asphalt cement.			

### Grades of Asphalt Cutbacks

When a great amount of cutterstock is added to a given amount of asphalt cement, a very thin liquid results. Viscosity grade is a measure of the relative consistency of an asphalt bitumen after cutterstock is added to a fixed amount of it. The grade is designated by a number that corresponds to the lower limit of the viscosity of asphalt cutback as determined by a standard test. The upper limit of viscosity is defined as twice the lower limit.

The viscosity grades of RC, MC, and SC are 70 (70-140), 250 (250-500), 800 (800-1,600), and 3,000 (3,000-6,000). The numbers in parenthesis are the lower and upper limits of viscosity. In addition, MC has a grade 30(30-60). The grade ranges are 30 (most fluid) to 3,000 (least fluid).

### Uses of Asphalt Cutbacks

Different types and grades of asphalt cutbacks are used to meet various climate conditions for different types of pavement. Asphalt cutbacks are usually used for prime/tackcoats and for bituminous surface treatments. The prevailing atmospheric temperatures existing during construction projects are a major factor in selecting the grade of asphalt cutback. The heavier grades are preferred for use in warm weather; the lighter grades in cool weather. When the preferred grade of a given type of asphalt cutback is not available, a comparable grade of another type may be substituted; for example, RC-800 maybe used instead of MC-800, or RC-70 instead of MC-70, without seriously affecting the finished pavement.

Light grades of asphalt cutback maybe produced in the field by adding solvents to asphalt cutback. The composition of asphalt cutbacks, expressed in percent of total volume, is shown in table 8-3.

### Asphalt Emulsions

An asphalt emulsion is a nonflammable liquid substance, composed of asphalt cement, water, and an emulsifier mixed together to produce a liquid material. Emulsions are environmentally friendly, have the same basic uses as cutbacks and are becoming more commonly used in the field. Asphalt and water will not mix; therefore, a chemical agent called an "emulsifying agent" must be added. The emulsifying agent keeps the asphalt cement suspended in the water and controls certain physical properties of the emulsion. Common emulsifying agents are soaps, animal blood chemicals, and certain specified colloidal clays in dust. When emulsion is applied to a surface, the water and asphalt cement break (separate), leaving a thin film of asphalt cement.

The speed of separation, referred to as *setting rate*, is the basis for designating an asphalt emulsion. The setting rates are rapid, medium, and slow. The letter symbols for these rates are RS, MS, and SS, respectively.

Asphalt emulsions are classified into two types: those that are negatively charged and those that are positively charged (table 8-4). Emulsified asphalts may be of either the anionic electro (negatively) charged asphalt globules or cationic electro (positive) charged asphalt globules. The asphalt emulsions are graded on the basis of viscosity and grouped according to their use.

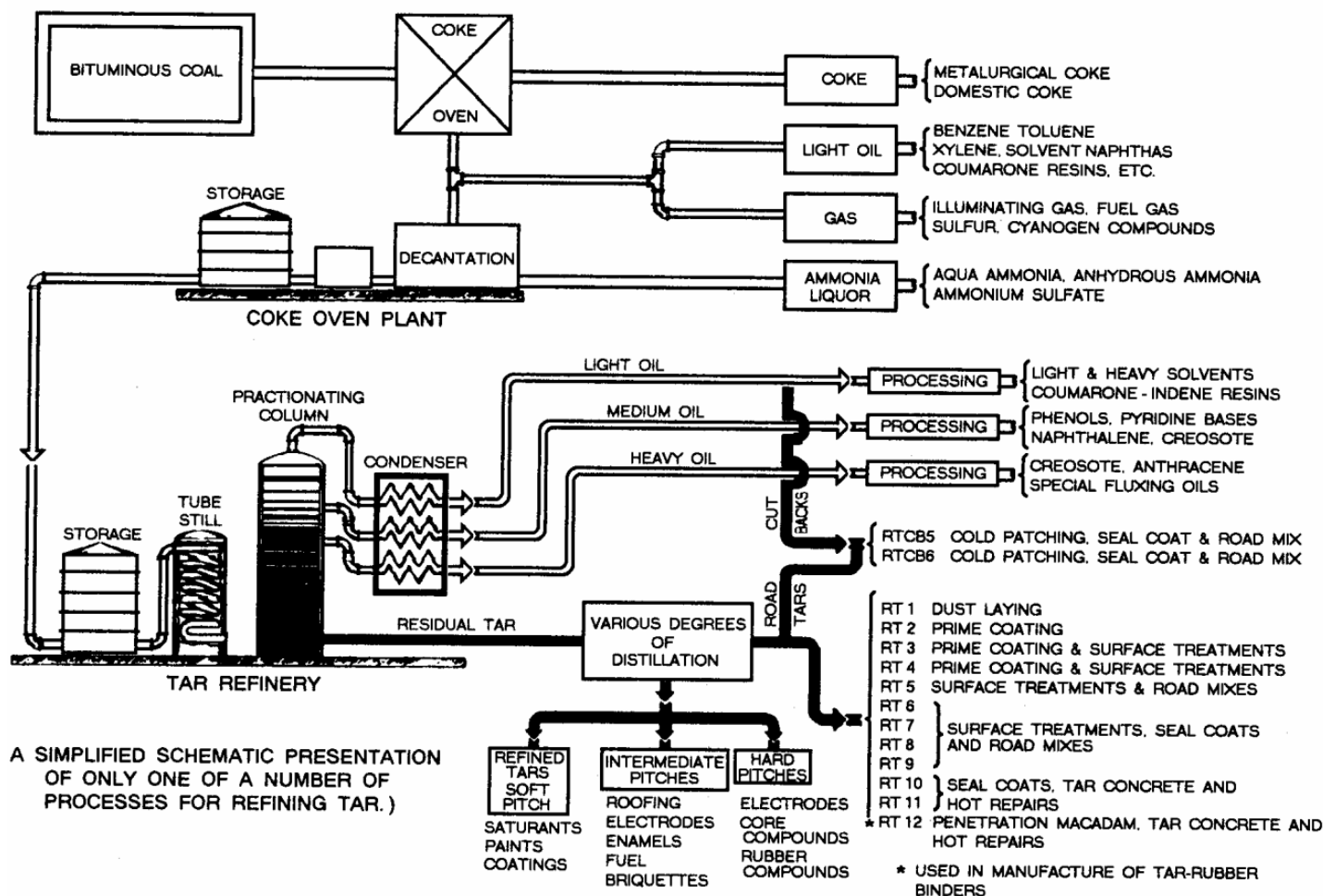


Figure 8-20.—Tars obtained from distillation of bituminous coal.

The viscosity grades range from 1 (least fluid) to 3 (most fluid).

### Use of Asphalt Emulsions

Emulsions are used for surface treatment, road and plant mixes, and crack and joint filling. The mixing grades can be mixed unheated with damp aggregate. They are preferred over asphalt cutback when the aggregate is very damp. Cationic emulsions coat damp aggregate better than anionic emulsion.

Recommended use of emulsions depends on setting rate and mixing ability. At water-freezing temperatures, asphalt emulsions do not mix well since the emulsion will separate from the water. Also, emulsions have a relatively short shelf life and tend to break while still in their unopen drums.

### Tars

Tars are obtained from the distillation of bituminous coal (fig. 8-20) and are seldom used in the NCF. A road tar is designated by the symbol RT and is manufactured in 12 grades of viscosity (table 8-5). RT-1, RT-2, and RT-3 are *PRIMING OIL*. RT-4 through RT-7 are called *COLD TARS* because they are fluid enough to be mixed and applied at relatively low temperatures. RT-8 through RT-12 are called *HOT TARS* because they are solid enough to require high temperatures for mixing and applying.

The symbol RTCB refers to *ROAD TAR CUTBACK*. RTCBs are manufactured only in viscosity grades 5 and 6. Coal distillate, such as benzene or a solution of naphthalene in benzol, may be used to cutback the heaviest grades of road tar to produce both grades of road tar cutbacks. The viscosity grades of road tars and road tar cutbacks can be compared to the